PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(72) Inventor FRED KERWIN FOX

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(54) ROTARY DRILLING TOOL FOR USE IN WELL BORES

(71) I, FRED KERWIN FOX, of 11220 Smithdale, Houston, State of Texas, United States of America, a citizen of the United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates in general to rotary drilling strings for use in drilling oil or gas wells. More particularly, it relates to improvements in tools of the type which are connected as a part of the string for increasing the drilling rate thereof.

In the drilling of oil or gas wells, a heavy fluid known as drilling "mud" is circulated downwardly through the drill string, out the bit at the lower end of the string, and upwardly through the annulus between the string and the well bore. Among other things, the mud aids in circulating cuttings from the well bore upwardly to the surface and controlling formation pressures within the bore.

Although necessary to the drilling of the well, the mud reduces the rate at which it may be drilled, which of course adds greatly to its cost. Thus, the hydrostatic pressure due to the mud creates a differential across the rock or other formation material at the lower end of the well bore which makes the material difficult for the bit to remove.

As shown, for example, in Sandstone U.S. Patent No. 2,352,412 and Yancey U.S. U.S. Patent No. 2,794,617, it has been proposed to increase the drilling rate by means of a tool connected in the drill string and having blades adapted to rotate with the string and spiraled in such a manner as to act as propellers or augers on the mud within the annulus. Thus, if the string is rotated at a sufficient speed relative to the circulation rate of the mud within the annulus, the blades will reduce the hydrostatic pressure of the mud at the lower end of the well bore. The downward reaction of the mud on the blades also contributes toward a higher drilling rate by increasing the load on the bit.

However, in order to increase the efficiency of these tools, it would be necessary to increase the speed of rotation of the string and thus the torque thereon to such an extent as to run the risk of twisting the string in two. Thus, as a practical matter, the efficiency of these prior tools is unpredictable and in any case rather low.

An object of this invention is to provide a tool of this type, in which the rate of rotation of the blades is not limited to the rate of rotation of the string.

The invention provides a rotary drilling tool, comprising a member connectable in a tubular drill string for rotation therewith within a well bore, a body about the member, at least one spiral projection on the outer side of the body, means for fluidly connecting the upper and lower ends of said member with the bore through the drill string for conducting drilling fluid downwardly therethrough, and means for rotating the body relatively to the member and in a direction to cause the projection to reduce the hydrostatic pressure of the drilling fluid in the annulus below the projection.

The blade can be rotated at a rate which is essentially independent of the rate of rotation of the string, which in turn makes it possible to decrease the hydrostatic pressure at the lower end of the well bore without a substantial increase in torque, and thus increase the drilling rate over that possible with prior tools of this type.

Preferably, the body comprises a sleeve which is spaced from the member to provide an annular passage between them, and the member has passageways in its upper and lower ends which connect with

the annular passage, to thereby fluidly connect with the bore of the string above and below the tool for circulating drilling mud therethrough. More particularly, the member and body are provided with means such as turbine blades for rotating the body merely in response to the circulation of mud through the annular passage.

The tool also preferably includes a pair of sleeves one above the other, with passageways in the member fluidly connecting the annular passages within both sleeves with one another as well as the bore of the drill string. More particularly, the propeller blades on the sleeves and the turbine blades or other means on the member and sleeves are oppositely arranged so that the sleeves are rotated in opposite directions. Consequently, the reactions of the mud on the propeller blades of the two sleeves are opposite, so that the increased torque requirements due to one sleeve are at least partially counterbalanced by the other.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a longitudinal, sectional view of a drill string including a tool constructed in accordance with the present invention and disposed within a well bore;

FIG. 2 is an enlarged detailed view of adjacent rows of turbine blades on the inner member and the upper outer sleeve of the tool; and

FIG. 3 is an enlarged detailed view of turbine blades on the inner member and the lower outer sleeve of the tool.

With reference now to the details of the above-described drawings, the lower end of the drill string, which is indicated in its entirety by reference character 10, is shown in FIG. 1 within a well bore 11, which may extend downwardly a substantial distance below the surface of the earth. The drill string is made up of a series of tubular members, including a drill collar 12 connected above and a drill bit 13 connected below the tool, which is indicated in its entirety by reference character 14. Obviously, this arrangement is merely illustrative of the use of the present invention, and it will be understood by those skilled in the drilling art that the tool 14 may instead be disposed at a location further up the drill string.

In any event, the outer diameter of the string is spaced from the well bore 11 to provide an annulus A through which drilling mud may be circulated upwardly to the surface. As will be described to follow, the tool fluidly connects the bores through the lower collar 12 and bit 13, so that the mud may be circulated downwardly therethrough and out the bit into the annulus. The string is rotated by well known means (not shown) at the ground surface.

The tool 14 includes a member 15 extending continuously between connection at its upper end to the drill collar 12 and at its lower end to the bit 13 so as to transmit torque from the collar 12 to the bit 13. The upper end has a box 16 for threaded connection to a pin on the lower end of the collar 12, and the lower end has a box 17 for threaded connection with a pin on the upper end of the bit 13.

The member 15 has upper and lower sections 15A and 15B of reduced outer diameter and separated by a central section 15C which is of substantially the same outer diameter as the upper and lower ends of the member 15. A sleeve 16A is spaced about the upper section 15A, and a sleeve 16B is spaced about the lower section 15B. As shown in FIG. 1, each of the sleeves is of substantially the same length as the reduced section which it surrounds, and is of an outer diameter substantially the same as that of the upper and lower ends of the member 15. Obviously the sleeves may be split longitudinally, or the upper and lower ends of the member 15 may be separable from the reduced sections thereof, so as to permit assembly of the sleeves about the reduced sections.

The lower end of the upper sleeve 16A is rotatably supported on a bearing 17 resting on the central section 15C, and the lower end of the sleeve 16B is rotatably supported on a bearing 18 resting on the upper end of the lower end of the member 15. As will be described to follow, sleeve 16A is adapted to be rotated in a right-hand direction and sleeve 16B in a left-hand direction, as the string itself is rotated in a right-hand direction.

As shown in FIG. 1, a pair of spiral propeller blades 28 and 29 are disposed about the upper sleeve 16A, and a pair of spiral propeller blades 30 and 31 are disposed about the lower sleeve 16B. More particularly, the blades on each sleeve are spaced apart 180°, and each make approximately one revolution about the sleeve. The outer edges of the blades extend outwardly from the sleeves to almost the well bore 11, so as to effect the hydrostatic pressure on substantially all of the mud within the lower end of the annulus. Alternatively, of course, the blades may extend outwardly to a sheath received closely within the bore, and the term "annulus" as used herein contemplates either an annulus defined between the sleeves and the well bore or between the sleeves and a sheath.

Although the blades tend to maintain the tool concentrically within the well bore, one or more centralizers are preferably mounted on the tool, such as that shown at 32 about the upper end of the member 15.

As previously described, and as shown in FIG. 1, the propeller blades 28 and 29 are spiralled in one direction, while the propeller blades 30 31 are spiralled in an opposite direction. More particularly, the blades 28 and 29 are spiralled in a direction which will tend to propel upwardly the mud within the annulus as the sleeve 16A is rotated in a right-hand direction, and the blades 30 and 31 are spiralled in a direction which will tend to propel the drilling mud upwardly when the sleeve 16B is rotated in a left-hand direction.

A seal ring 19 carried by the inner diameter of the upper end of sleeve 16A sealably surrounds the upper end of the section 15A, and a seal ring 20 carried by the inner diameter of the lower end of the sleeve 16A sealably surrounds the lower end of such section, thereby forming an annular passageway 21 between the section 15A and sleeve 16A. In like manner, a seal ring 22 carried by the inner diameter of the upper end of the sleeve 16B and a seal ring 23 carried by the inner diameter of the lower end thereof sealably surround the upper and lower ends of the member section 15B, respectively, to form an annular passageway 24 between the member 15B and the sleeve 16B.

There is a passageway 25 in the upper end of the member 15 which forms a smooth continuation of the bore through the drill collar 12 at its upper end and branches at its lower end to connect with the annular passageway 21. There is also a passageway 26 in an intermediate portion of the member 15 which has branches at its upper end connected to the lower end of the annular passageway 21 and branches at its lower end connecting with the upper end of the annular passageway 24. A further passageway 27 in the lower end of the member 15 has branches at its upper end which connect with the lower end of the annular passageway 24 and forms a smooth continuation of the bore through the bit 13. Thus, as previously mentioned, passageways through the tool 14 fluidly connect the bores through the drill string above and below the tool.

A plurality of rows of turbine blades 35 are disposed in vertically spaced-apart locations along the upper section 15A of the member 15, and a plurality of rows of turbine blades 36 are disposed in vertically spaced-apart relation about the inner side of the sleeve 16A. More particularly, the rows of blades 35 and 36 are arranged alternately and overlap within the annular passageway 21 so as to form a plurality of turbines. As illustrated in FIG. 2, the blades 35 on the member section 15A extend at an angle to the vertical axis of the member which causes them to be moved in a clockwise direction in response to the downward flow of drilling mud within the passageway 21. On the other hand, the blades 36 on the sleeve 16A are slanted in the opposite direction so that the reaction of the mud on them is in the opposite rotational sense. Thus, the downward flow of drilling mud in the annular passageway 21 will cause the sleeve 16A to rotate relative to the member 15 in a right-hand direction.

Similarly, turbine blades 37 are arranged in vertically spaced-apart rows about the lower member section 15B, and turbine blades 38 are disposed in vertically spaced-apart rows about the inner side of the sleeve 16B, with the rows of blades 37 and 38 overlapping and alternating vertically. However, as distinguished from the blades 35 and 36, the blades 37 and 38 are arranged to cause the sleeve 16B to rotate in a left-hand direction in response to the flow of drilling mud downwardly through the passageway 24. Thus, the blades 37 are angled oppositely to the blades 35, and the blades 38 are disposed oppositely to the blades 36.

In the illustrated embodiment of the invention, the turbines in the annular passageways 21 and 24 are of equal capacity so that each of the sleeves 16A 16B will be rotated at generally the same speed relative to the member 15 and thus operate at substantially the same efficiency. However, the speed of the upper sleeve 16A relative to the well bore will be greater than the speed of the lower sleeve 16B relative thereto, so that the counter-torque effect of the lower sleeve 16B will not fully equalize the added torque requirement due to the sleeve 16A. However, the lower sleeve 16B will at least reduce the added torque requirements which the sleeve 16B would otherwise impose on the drill string. Furthermore, it will be apparent that the capacity of the lower turbine may be increased so as to fully compensate, or actually overcompensate, therefor.

WHAT I CLAIM IS:—

1. A rotary drilling tool, comprising a member connectable in a tubular drill string for rotation therewith within a well bore, a body about the member, at least one spiral projection on the outer side of the body, means for fluidly connecting the upper and lower ends of said member with the bore through the drill string for conducting drilling fluid downwardly therethrough, and means for rotating the body relatively to the member and in a direction to cause the projection to reduce the hydrostatic pressure of the drilling fluid in the annulus below the projection.

2. A tool as defined in Claim 1, wherein the body comprises a sleeve spaced about the member to provide an annular passage-

way therebetween, the connecting means comprises passageways in the upper and lower ends of the member connecting with the annular passageway and the means for rotating the sleeve comprises means on said member and sleeve and responsive to the flow of drilling fluid through said annular passageway.

3. A tool as defined in Claim 1, wherein the body comprises a sleeve spaced about the member to provide an annular passageway therebetween, the connecting means comprises a passageway connecting one end of the annular passageway with the bore through the drill string and another passageway providing an outlet from the other end of the annular passageway to cause drilling fluid in the bore to flow through said annular passageway, and a means for rotating the sleeve comprises means on said member and sleeve and responsive to the flow of drilling fluid through said annular passageway.

4. A tool as defined in Claim 2 or Claim 3, wherein said rotating means comprises turbine blades on said member and sleeve.

5. A tool as defined in Claim 1, including a second body about the member below the first-mentioned body, at least one spiral projection on the outer side of the body arranged oppositely to the projection on the first-mentioned body, and means for rotating the second body relatively to the member and in a direction opposite to the direction in which the first-mentioned body is rotated so as to also cause the projection on the second body to also reduce the hydrostatic pressure of the drilling fluid in said annulus below the projection.

6. A tool as defined in Claim 5, wherein the bodies comprise a pair of sleeves each spaced about the member, one above the other, to provide an annular passageway between it and the member, the connecting means comprises passageways in the member connecting with the annular passageways between the sleeves and member, and the means for rotating the sleeves comprises means on said member and each of said sleeves and responsive to the flow of drilling fluid through the annular passageway between the sleeve and member.

7. A tool of the character defined in Claim 5, wherein the bodies comprise a pair of sleeves each spaced about the member, one above the other, to provide an annular passageway between each sleeve and the member, the connecting means comprises a passageway connecting one end of the annular passageway within each sleeve with the bore through the drill string and another passageway providing an outlet from the other end of each annular passageway to cause drilling fluid in the bore to flow through said annular passageway, and the means for rotating the sleeves comprise means on said member and each of said sleeve responsive to the flow of drilling fluid through the annular passageways.

8. A tool as defined in Claim 6 or in Claim 7, wherein said rotating means comprises turbine blades on said member and each of said sleeves.

9. A rotary drilling tool substantially as hereinbefore described with reference to the accompanying drawings.

TREGEAR, THIEMANN & BLEACH
Chartered Patent Agents,
Agents for the Applicant,
Melbourne House,
Aldwych,
London, W.C.2.

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1306568 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

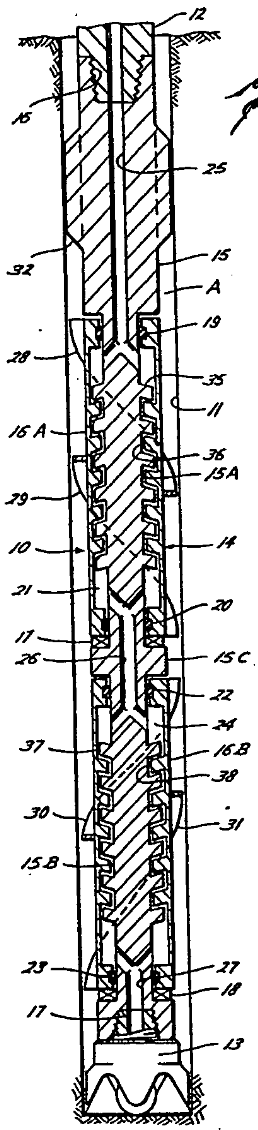

Fig. 1

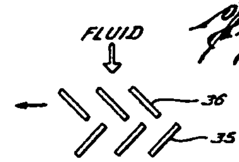

Fig. 2

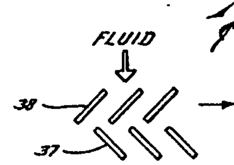

Fig. 3